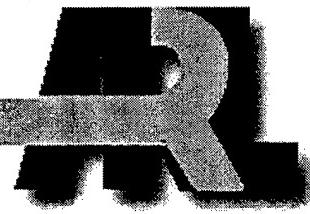


ARMY RESEARCH LABORATORY



The Effect of Wearing Night Vision Goggles on
Voice Level During a Visual Target
Acquisition Task

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Abstract

There have been numerous undocumented reports that military users of night vision goggles (NVGs) tend to talk louder than usual when they wear the viewing device. Increased voice level in response to using the night vision aid could seriously compromise the security of military missions that depend upon stealth for their success. The goal of this study was to investigate the effects of characteristics of the NVGs such as display resolution, field of view, and physical constraint on the voice level of NVG users as the users described military activity of potential targets seen during a visual target acquisition task. The experiment was conducted indoors without the presence of situational variables or psychological stressors ordinarily found in the field. The authors wished to determine whether voice level depended on the physical characteristics of the NVGs. No effect of physical characteristics of the NVGs was observed. The influence of situational variables on the vocal output of NVG users will be examined in a future experiment. Some aspects concerning the procedures used to measure voice levels and to develop a realistic visual target acquisition task are discussed.

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THE EFFECT OF WEARING NIGHT VISION GOGGLES ON VOICE LEVEL DURING A VISUAL TARGET ACQUISITION TASK

INTRODUCTION

Night vision goggles (NVGs) have been of inestimable value to the U.S. armed forces and to civilian organizations concerned with security. For a major application of NVGs in a military context such as nighttime surveillance, the use of the visual aid is obviously superior to using none at all. Although NVGs possess some potential visual shortcomings such as limited resolution equivalent to having a visual acuity of only 20/40 (as measured with a Snellen eye chart) and a limited field of view (FOV) of only 40°, such factors probably prove to be minor limitations when compared to the overall usefulness of NVGs. However, there may be a property of NVGs that is potentially critical to the safety of the user. There have been numerous undocumented reports that users of the device have a tendency to talk noticeably louder while wearing NVGs than when they are not wearing them, even though the users are fully aware of the effect. Such accounts have been given by (among others) members of the Army's special forces. Some of their personnel claim that they are aware of a voice effect, and during stealth conditions, they try not to use NVGs if possible. The effect potentially compromises a military mission that depends upon stealth for its success. If it can be substantiated, the phenomenon poses some fundamental questions about why the voice level of a user might be affected by NVGs even though access to the ears of the user appears to be unobstructed by the device.

Many hypotheses can be devised to explain or speculate about the phenomenon of talking loudly when NVGs are worn. One is that the user's task of interpreting the world, as seen through a small, bright display with a limited FOV, while the user is immersed in the surrounding darkness, may produce a cognitive or attentional tunneling effect (Wickens, Thomas, Merlo, & Hah, 1999; Yeh & Wickens, 1999) that leads to a deficit in peripheral sensory awareness. This effect might give the user a sense of isolation that must be overcome. Overcoming that isolation while talking with another person at an unknown location in the surrounding darkness perhaps translates into an increase in voice level. Another hypothesis concerning the phenomenon involves the stress level of the NVG user (National Research Council, 1997). Such a device would normally be required on a night mission during periods of high risk. It is easy to imagine that the mix of potential danger with the need for stealth and the responsibility for the safety of others might exaggerate the sound of any voice above a whisper. Other hypotheses about the phenomenon involve notions that voices may sound louder in the dark because there are fewer visual distractions, or perhaps the urgency of warning others of potential danger may increase the voice level. The feel of the NVGs' being worn on the face may produce a need to overcome the obstacle by talking louder. Perhaps the use of a head-mounted display with a limited FOV and the need to keep a continuing visual event in constant sight exaggerate the necessity of not turning away from the event to talk with another person for fear of losing visual orientation in the display. The need to retain the head position may cause the voice level to rise during the relayed reporting of the visual event. Finally, in a nighttime, military field situation, because of the necessity for stealth, talking is infrequent. Occasionally, urgent commands such as "stop," "wait," or "get down" may

simply sound louder than normal in the quiet of the night. Surprisingly, these issues did not trigger much research interest in the past and no reliable data are available.

Identifying the cause of the phenomenon, if it exists at all, of increased voice level when NVGs are worn is important for both the user and the NVG designer in order to minimize or eliminate the effect for the safety and survival of the user. Such means may include side-tone amplification (Chang-Yit, Pick, & Siegel, 1975), NVG redesign, or specialized training and may differ according to both the cost and the time needed for implementing modifications.

OBJECTIVES

The primary objective of this study was to determine if the phenomenon of increased voice level associated with NVG use could be reproduced in the laboratory during more controlled conditions than would be available in the field. If so, this study of the phenomenon would not only be greatly simplified but might also provide specific information about whether it had any basis in the purely physical aspects of using NVG displays. In other words, the authors wished to determine if such elements as limited FOV and resolution, the weight of the display or the restriction of its supporting head harness played significant roles in the phenomenon. Secondary objectives of the study were to

1. Construct a realistic, visual target acquisition task that involved moving targets at close range (on average, 20 m) in order to simulate the domain within which the phenomenon was reported, and
2. Develop a method for measuring speech levels that might occur during such a task.

These objectives, if successfully achieved, could have further applications in studying the behavior of soldiers in their environment.

METHOD

General

The critical elements of viewing condition and scene characteristics that might contribute to the phenomenon of talking loud are unknown. Therefore, our approach was to investigate the effects of NVG characteristics such as display resolution, limited FOV, and the physical constraint of the NVG harness itself. Incidentally, the weight of the device (close to 700 grams), extends outward from the head of the observer and creates a load vector that must be supported by a substantial, tightly worn head harness. For scene characteristics, the concern was to employ as many dynamic visual elements in the scene content as possible, which might exist in a natural outdoor environment.

A dynamic, target acquisition task incorporating elements of target motion and uncertainty of target event occurrence was chosen for use to keep within the context of what a realistic night vision scene might presumably encompass. It was deemed necessary to include

task elements requiring visual observation, cognitive processing, and, of course, voice communication. It was also necessary to present participants with a task that elicited sufficient involvement to immerse them in the context of playing the role of an actual observer in the field who was required to communicate a running description of a changing scene to another person.

Participants

Twenty male participants (herein called "observers") between 18 and 53 years of age, with a mean of 34 years, from various National Guard units, volunteered and were paid for their participation in this experiment. All observers had minimally 20/30 visual acuity (corrected or uncorrected) in both eyes and normal stereoscopic vision. A Titmus® II vision tester was used to screen the observers. In addition, all observers had pure tone hearing thresholds within normal limits (i.e., better than 25 dB HL¹ for octave frequencies from 250 through 8000 Hz as per American National Standards Institute [ANSI] S3.6-1996). Hearing testing was conducted in a room with background noise levels complying with clinical requirements for earphone testing (ANSI, 1991).

Visual Stimuli

The stimulus set consisted of front-projected images of color video scenes of wooded areas showing "live footage" of a militarily relevant activity. The average scene duration was about 20 seconds, with a standard deviation of 3 seconds. A four-digit identification number was first shown in the center of the viewing area, about 5 seconds before the onset of each scene, and lasted for about 4 seconds. This number served as (a) an initial visual fixation point for the observer, (b) a label for locating the correct scene on the observer's voice recording of the stimuli, and (c) a neutral stimulus as a verbal reference for evaluating voice levels associated with different viewing conditions. Because of the large number and variety of scene characteristics that the authors wished to include as elements in the stimuli, a great number of reasonably realistic scenarios were recorded in order to select from those scenes the ones that best fit the requirements. About 55 scenes were videotaped.

A typical video scene contained various combinations of a moving soldier and silhouettes of stationary soldiers. Static and dynamic scene variables involved the presence or absence of a moving target, the number of stationary targets (none, one, or two), and the apparent distances of the targets (from 5 to 50 meters) to the observer viewing the scene. Other scene characteristics were the denseness of the foliage (low, medium, or high) in the vicinity of the targets and the proportion of the moving target (low, medium, or high) obscured by the foliage. More dynamic elements involved the amount of movement (low, medium, or high) of the foliage caused by wind, and the amount (fast or slow movement) and type of movement of the target (e.g., either approaching the observer or moving across the scene relative to the observer's line of sight). Important target characteristics concerned the physical behavior of the moving soldier in the scene and whether a weapon was present and

¹Hearing level - a logarithmic measure of hearing loss in reference to a standardized threshold level (ANSI 1994).

being held in a neutral position or being aimed. The soldier in the scene could aim the weapon in any direction and could appear to aim at the observer.

Stimulus Selection

After the 55 scenes were videotaped, five people acting as judges viewed each scene without visual aids and rated it for the relative difficulty of detecting the moving target. Thirty scenes of the 55 were selected for use as final stimuli on the basis of creating a distribution of scene difficulty ratings from moderately difficult to very difficult. Those scenes in which the target was highly visible (i.e., it presented no search challenge to the observer) were not chosen. Scenes were selected according to (a) how much time it took to discover the moving target and the silhouettes and (b) how broad the representation was of the previously mentioned scene characteristics. Some scenes with no target were also chosen. The final group of 30 scenes was then divided into five groups of six scenes each so that there was a reasonable balance of the relevant stimulus elements in each group. Five video cassettes of the scene groups were prepared to facilitate randomization, and these were shown to the observers during each of the different viewing conditions.

Viewing Condition

Each of the observers viewed the videos during five different conditions:

1. NVGs with reduced resolution equivalent to a visual acuity of 20/70 (Snellen);
2. NVGs with normal resolution equivalent to 20/40 (Snellen);
3. Mock goggles possessing the physical characteristics of weight (approximately 700 grams) and FOV (40°) similar to the NVGs but without optics;
4. The NVG harness alone with no goggles attached; and
5. No viewing apparatus worn on the head.

Apparatus

A theater-type environment was used to present the stimuli. It consisted of a large ($v = 1500 \text{ m}^3$; 17 m long by 13 m wide by 7 m high), acoustically treated room with reverberation time (RT) < 0.5 second, in the frequency range from 125 to 4000 Hz. The center region of this space was an acceptable approximation of outdoor listening conditions for low- and mid-level acoustic stimulation. A low-level (40 to 50 dBA), recording of natural outdoor woodland sounds was used for the background noise to boost the realism of the simulation and to mask any distracting noises.

The instrumentation used to present the stimuli included a video tape deck, a video projector, and a 20-ft by 13-ft projection screen at a viewing distance of 20 feet from the observer. The video projection equipment was located behind the observer in a projection room acoustically isolated from the theater environment. A secure viewing platform, 4 feet high, was built on the theater floor to allow the observer's eye level to be even with the eye level of the soldiers depicted in the video scenes, at about the center of the screen height. The soldier in the scenes nearest the camera that recorded his activity was (on average) photographed at a similar distance from the camera as the observer-to-screen viewing distance. The visual angle subtended by a target on the screen was similar to the visual angle subtended in the actual environment.

The instrumentation used for the viewing conditions consisted of binocular AN/PVS-7B NVGs with head harness. The goggles used an integral battery compartment that contained two standard AA batteries. The total head-borne weight of the device was 695 grams. In order for the NVGs to be used to view projected videos, a lens cap with a pinhole was used on the object lens. Normal resolution of the goggles, with or without a pinhole, was equivalent to the wearer having a visual acuity of 20/40, Snellen. In the 20/70 Snellen condition, adding diffusing material over the pinhole reduced the viewing acuity. A lens cap with either a clear or with a diffusing pinhole was used for the two NVG viewing conditions. In-house fabricated mock goggles that simply limited the FOV to 40° without optics and that had the same weight as the NVGs were used as a third viewing condition. A fourth viewing condition consisted of the NVG harness by itself. NVGs were first harnessed onto the head of the observer to firmly secure them; then, the goggles were removed, leaving only the harness in place.

The instrumentation used to record the observer's verbal reports consisted of a microphone and digital audio tape recorder and an audio calibration device. The instrumentation used for storing, processing, and analyzing the voice data consisted of an IBM 586 computer and monitor, signal-editing software, and software for measuring sound quality.

Procedure

Each observer was shown short videos, each approximately 20 seconds in duration, of wooded scenes. The observer's task was to continuously search for and verbally report the occurrence (as it was happening) of any activity of military significance during the scene video. A typical military activity might consist of a soldier appearing, holding a weapon, and moving in some direction. The soldier in the scene sometimes appeared to aim the weapon toward the observer. In some scenes, silhouettes of soldiers appeared as well.

Each observer was asked to imagine that he was on a military night mission, leading a small squad of soldiers through a wooded terrain. He was the only person in the squad wearing NVGs and had to be the "eyes of the squad," required to report anything of importance so that danger could be successfully avoided. No reference to "stealth" was mentioned. The experimenter played the role of a squad member immediately behind the observer. The four-digit identification number that preceded each scene was first reported. When the scene began, the observer reported any important terrain details such as hills,

gullies, or undergrowth that might have to be avoided, or the presence of any paths through the woods. Upon sighting a target, the observer was instructed to immediately report what the target was, such as a moving soldier. This was to be followed by a report of the apparent location of the target according to the clock values of from 9 o'clock, (the left side of the view), to 12 o'clock, (straight ahead), to 3 o'clock, (the right side of the view). After reporting the location, the observer was to estimate and report the apparent distance of the target from the viewing position. This information was to be followed by a description of what the target was doing. The observer was to report the soldier's direction of movement, if any, in which direction a rifle was aiming, if the soldier appeared to be holding a rifle, and especially, if the soldier in the scene appeared to see the observer.

The observers were shown the videos in all five viewing conditions. For all conditions, they wore a soldier's field cap with a microphone attached to its brim and connected to a small tape recorder in a pouch worn over the shoulder. The microphone was always at the same distance from the observer's mouth, with no restriction of head movement. Observers were told that their verbal descriptions were being recorded for future analysis of the kinds of descriptions soldiers used in such a task. At no time were they told that the authors were interested in how loudly they were talking nor was a reference ever made to any scenario requiring stealth.

During the practice session in which three scenes were used to instruct the observer about the kind of information to report, no goggles were worn. The configuration of the viewing area required the experimenter to be situated behind a partition 8 feet to the rear and side of the viewing platform upon which the observer stood. The observer's reports were digitally recorded during all sessions in order to document their verbal content, temporal characteristics, and voice level. Observers were told that the experimenter, playing the role of a squad member, was similarly unable to see each scene and would be situated behind a partition, making notes about what kind of information was being verbally communicated.

The stimulus materials were front projected onto the 13- by 20-foot viewing screen in the darkened room. The observer stood on the viewing platform at approximately eye level with the center of the screen at a distance of 20 feet from the screen and described to the experimenter what was seen. This geometry produced viewing angles with the screen of approximately 36° by 53° . The viewing angle of the NVGs was approximately 40° , thus requiring the head to move horizontally to see the whole scene. For each viewing condition, the observer donned the appropriate viewing apparatus and observed six video scenes.

Experimental Design

A within-subjects design was used for the independent variable of viewing condition with five levels. The viewing conditions were presented in a counterbalanced design, based on two 5 by 5 Greco-Latin squares so that each viewing condition followed every other condition exactly two times. The five video cassettes were paired with the viewing conditions in a similar design, also based upon two superimposed 5 by 5 Greco-Latin squares.

Each video cassette presentation both followed and preceded equally every other video cassette and was shown an equal number of times, with each of the viewing conditions for a total of 20 observers.

The dependent measure was the voice level of the observer. A calibration signal (recorded before the observer entered the theater) was followed by the voice of the observer reading the scene identification numbers and the verbal descriptions of the scene contents, which were tape recorded and later stored in computer data files for analysis. The signal-editing software was used to display individual voice files on the computer screen and to measure appropriate sound levels during the data analysis. For the verbal description of the scene content, all pauses in the sound record were first removed to reduce any effect of silence on the measurement of the mean voice level for a scene. A pause was defined as the cessation of speech between phrases or while the observer was waiting for some activity to occur in the scene. After the pauses were edited, the final sound record of an observer consisted of all the words and phrases appearing at approximately equal time intervals. No sound editing was performed on the verbalizations of the scene identification numbers. Sound levels were measured as root mean square (rms) energy levels in dBA units².

RESULTS AND DISCUSSION

In order to compare voice levels, average loudness level and average speech sound pressure (rms) level were to be used initially as the dependent variables. A sound quality software program was used to calculate loudness data. However, the differences between loudness levels were very similar to the differences between rms levels as measured by the signal-editing software. This was because all the voices had very similar spectral content. Therefore, all calculations were completed and are reported using rms data that were easier and faster to obtain.

The Effect of NVGs

The average rms levels of observers' voices are reported in Tables 1 and 2. The data in Table 1 were obtained for verbalized scene content, while the data in Table 2 were obtained for verbalized pre-scene identification numbers. The analysis of rms voice levels pertaining to the content of each scene revealed no significant differences between any of the viewing conditions. Averaging the data across all observers, the voice levels for viewing condition ranged from means of 75.6 to 76.5 dBA, with standard deviations from 8 to 9 dB. The fact that observed speech levels were higher than the typical levels for conversational speech (normally 60 to 65 dBA) probably indicated that the observers were attempting to communicate with the unseen person (the experimenter) located somewhere behind a partition to the rear of the observer's viewing position.

²dBA = weighted measure of sound pressure level using A-weighted sound pressure (ANSI 1994).

Table 1
Rms Voice Level (dBA) for Scene Content

Subjects	70 NVG	40 NVG	Viewing condition		
			MOCK	HARN	NONE
1	81.8	80.7	80.7	76.7	79.0
2	82.6	83.6	83.9	84.8	82.4
3	83.0	81.0	83.9	82.8	79.5
4	79.0	80.5	80.1	81.5	78.6
5	85.4	81.3	82.1	82.9	81.2
6	70.9	70.1	71.7	72.7	72.9
7	66.9	69.1	71.2	71.7	72.1
8	76.5	80.1	77.6	80.8	72.8
9	75.2	74.1	78.8	80.4	76.3
10	80.3	75.8	77.0	80.3	80.0
11	78.8	79.8	81.5	80.1	80.2
12	77.5	79.3	77.8	77.9	77.3
13	62.8	64.5	62.0	63.6	66.1
14	57.9	58.1	60.2	64.3	60.2
15	81.7	83.3	80.2	80.7	85.3
16	79.2	78.5	76.2	76.5	78.0
17	75.0	77.0	77.2	75.9	74.2
18	84.4	84.1	84.5	84.1	84.2
19	81.9	81.8	84.1	79.4	80.4
20	52.8	52.1	53.4	53.2	51.8
SUM	1513.6	1514.8	1524.1	1530.3	1512.5
MEAN	75.7	75.7	76.2	76.5	75.6
SD	9.0	8.8	8.6	8.0	8.2

Likewise, an analysis of the rms voice levels of the pre-scene identification numbers revealed no differences between viewing conditions. The average voice levels ranged from 76.1 to 76.6 dBA, with standard deviations from 6.7 to 7.6 dB. Of specific interest is that the voice levels for the identification numbers (an assumed neutral source of stimuli) and scene content (an assumed highly variable source of stimuli) differed from each other by only about 0.5 dB, on average. In other words, their rms levels were almost identical. This result was surprising in view of the fact that during data collection, when observers were describing some scenes, they appeared to be responding quite differently to provocative actions of the moving soldier in the scene. For example, if the moving soldier began aiming his weapon at the observer, the response was to speak more excitedly in contrast to a more monotonic verbalization of other portions of the scene. Furthermore, this effect appeared to be unrelated to whether the

observer was wearing goggles. This observation called for an additional data analysis of peak rms voice levels in scene reports rather than average rms voice levels which could diminish the effect of peaks. There was a possibility that a difference between viewing conditions might be observed in speech levels of single isolated words or phrases uttered in response to a "perceived threat." An analysis of short-term response events occurring within each scene was performed on all scene data. A short-term response event was defined as the rms level of a verbalized phrase of 2-second duration that included the maximum peak vocalization of the scene. These data are shown in Table 3. An analysis of the rms peak levels similarly revealed no differences between viewing conditions. The peak levels ranged from 76.6 to 77.5 dBA, with standard deviations from 8 to 9 dB.

Table 2
Rms Voice Level (dBA) for Identification Number

Subjects	Viewing condition				NONE
	70 NVG	40 NVG	MOCK	HARN	
1	80.8	80.0	78.2	75.6	77.4
2	79.1	80.6	81.5	80.9	78.8
3	85.1	83.3	85.3	83.9	81.9
4	79.1	80.8	80.0	82.4	79.7
5	85.9	81.0	82.3	81.9	80.9
6	71.6	73.1	73.3	74.7	74.6
7	69.1	73.0	75.1	72.7	74.7
8	77.4	77.8	74.7	77.8	71.0
9	78.4	79.0	82.0	82.4	78.8
10	80.1	77.5	77.3	80.4	81.1
11	78.6	78.8	76.6	79.7	80.5
12	77.9	79.0	78.0	78.0	76.3
13	62.2	62.7	61.8	61.5	66.8
14	61.3	59.7	62.2	66.1	62.1
15	82.0	82.9	81.3	80.1	84.2
16	80.0	79.2	77.2	77.6	78.7
17	75.3	76.2	76.5	74.6	73.1
18	85.6	83.4	84.9	84.2	84.4
19	79.6	78.5	80.4	76.3	77.1
20	61.1	60.1	61.7	61.8	60.3
SUM	1530.2	1526.6	1530.3	1532.6	1522.4
MEAN	76.5	76.3	76.5	76.6	76.1
SD	7.6	7.3	7.1	6.7	6.7

An additional question raised was whether either of the measures, the average rms voice level or the peak rms voice level, were a suitable measure for discriminating between observed levels of a "perceived threat." To help answer this question, it was decided to closely examine a certain portion of scenes in which (during data collection) observers appeared to respond to a perceived threat with increased voice level. The authors wished to see if the rms voice level measures would discriminate between verbal responses to neutral activity and verbal responses to more provocative actions of the soldier in the scene. Since such a thematic factor affecting voice level was not initially considered as a component in the original scene selection criteria, all 30 scenes used in the experiment were re-evaluated for the presence of "perceived threat" after all the data were collected.

Table 3
Rms Peak Voice Level (dBA) Within Scenes

Subjects	Viewing condition				NONE
	70 NVG	40 NVG	MOCK	HARN	
1	83.6	82.5	83.0	77.5	80.6
2	82.2	85.2	85.0	84.1	82.2
3	83.6	81.6	84.7	84.6	81.6
4	80.4	81.4	81.7	83.2	80.3
5	87.0	82.9	83.1	83.7	82.3
6	71.0	71.6	72.5	72.2	73.9
7	68.3	69.4	72.4	72.2	73.2
8	78.6	82.5	78.3	83.9	75.4
9	76.5	74.9	80.7	81.7	77.7
10	82.1	78.3	78.0	82.7	81.9
11	80.4	80.3	83.4	82.2	82.3
12	78.8	81.6	78.8	79.5	77.7
13	65.4	66.1	63.5	65.4	68.4
14	58.6	57.6	62.1	65.7	60.5
15	82.8	83.6	79.9	80.7	85.0
16	78.6	78.7	76.4	76.1	78.5
17	74.5	77.1	77.4	75.5	73.7
18	84.3	83.7	83.9	84.1	83.4
19	82.3	82.1	83.9	79.7	81.3
20	54.0	53.9	54.5	54.3	52.7
SUM	1533.0	1535.0	1543.2	1549.0	1532.6
MEAN	76.7	76.8	77.2	77.5	76.6
SD	8.9	8.8	8.4	8.0	8.1

The Effect of Perceived Threat

Ten people who were not participants in the experiment volunteered to serve as judges. Without using goggles, they were shown the 30 scenes in the same instructional context as the observers in the experiment had been given, that is, to imagine they were covertly observing a wooded area at night with the aid of a night vision device. Judges independently rated each scene from 1 to 5 on the basis of how threatening or intimidating the target activity in the scene appeared to be to them. A rating of 1 was no threat, 2 was low threat, 3 was moderate, 4 was high, and 5 was very high threat. Judges reported afterward that they primarily rated a scene based on whether the soldier in it appeared to actually point a rifle at them. Other elements such as the nearness of the soldier, the speed and direction of his movement, and how visible he was were also judged to be important to their ratings. Table 4 shows the threat ratings of the ten judges.

It can be seen that, of the 30 scenes rated, 19 scenes achieved agreement on their ratings by a majority of 6 to 10 of the raters. Initial efforts at balancing the distribution of dynamic scene characteristics within each video cassette resulted in finding that each one contained at least one scene at the rating of 5, "very high threat" level, and all but one cassette contained at least one scene at 2, "low threat" level. In the one cassette, the scene chosen for use as low threat, although not agreed upon by a clear majority of the raters, attained the lowest average threat rating of 1.6. The voice data from these 10 scenes were analyzed in a similar manner as before for the effect of perceived threat on voice level. The nine remaining scenes of high agreement among the judges, plus the 11 scenes with ratings of insufficient agreement (fewer than six judges agreeing) were not used for the analysis.

Average voice levels (in dBA) for the five scenes with the highest (T5) and the five scenes with the lowest (T2) "perceived threat" are shown in Tables 5 and 6. A small but statistically significant difference was found between high and low perceived threat scenes, based on rms averages of the entire scene content. High threat scenes were approximately 0.9 dB louder, on average, than low threat scenes, $F(1, 19) = 12.395, p = 0.002$. However, similar differences were found for the pre-scene identification numbers. Identification numbers associated with high threat scenes were 0.9 dB louder, on average, than identification numbers associated with low threat scenes, $F(1, 19) = 32.908, p < 0.001$. Since the identification number always preceded the scene, it was impossible for it to reflect any differences in scene threat ratings. Therefore, the observed differences were probably spurious and cannot be considered as resulting from differences in the perceived threat.

An analysis of peak rms voice levels for the scenes with the highest and the lowest "perceived threat" was performed as well. Peak data are presented in Table 7. No significant differences were found between threat levels or between viewing conditions. Although the means were similar to those in Table 5 for average rms, apparently the variances were high enough to negate any differences between them.

Based on these data, it may be concluded that the effect of perceived threat on the observers' voice levels during the present study conditions could not be demonstrated. However, perceived threat was clearly reflected in changes in voice quality and speech rate.

Future studies may determine whether any quantitative measures based on voice quality and speech rate may be developed to assess a soldier's level of arousal.

Table 4
Ratings by 10 Judges of Perceived Threat for 30 Scenes

Scene No.	Judged ratings										Mean	SD ^a	Mode (N=)				
	sn	ab	tg	bv	jp	lw	eh	jb	kn	gk			10	9	8	7	6
3017	2	2	3	4	3	2	3	3	2	3	2.7	0.675					
4031	1	1	2	2	3	1	2	3	3	2	2.0	0.816					
9040	1	1	1	1	2	1	1	1	1	1	1.1	0.316		1			
2106	5	5	5	5	5	5	3	5	5	5	4.8	0.632		5			
4301	5	5	5	5	3	5	5	5	5	5	4.8	0.632		5			
1452	1	1	2	2	2	2	2	2	1	3	1.8	0.632				2	
7485	5	2	4	2	2	4	4	5	2	4	3.4	1.265					
0159	5	5	5	5	4	5	5	5	5	5	4.9	0.316		5			
6192	2	1	2	2	3	3	2	2	3	2	2.2	0.632			2		
5263	2	2	3	3	3	3	3	4	4	3	3.0	0.667			3		
4317	2	1	3	2	1	1	1	3	3	2	1.9	0.876					
1340	5	5	5	5	5	5	5	5	5	5	5.0	0.000		5			
6074	4	4	3	3	4	4	4	5	3	4	3.8	0.632					4
3471	1	1	1	1	1	1	2	5	1	1	1.5	1.269		1			
7126	2	2	2	2	1	2	1	3	2	2	1.9	0.568			2		
1529	5	3	4	3	4	4	3	5	4	3	3.8	0.789					
1275	5	5	5	5	5	5	5	5	5	5	5.0	0.000		5			
5360	2	3	2	2	2	3	2	3	2	2	2.3	0.483			2		
2058	1	2	1	1	1	2	1	1	1	1	1.2	0.422			1		
6091	3	2	3	2	2	3	3	4	2	2	2.6	0.699					
5174	5	5	5	5	5	5	5	5	5	5	5.0	0.000		5			
9180	2	3	2	2	2	3	2	2	3	2	2.3	0.483			2		
3286	2	4	3	3	3	3	2	4	3	3	3.0	0.667			3		
1467	2	3	3	4	3	3	2	4	2	3	2.9	0.738					
8371	5	5	3	4	4	4	5	5	5	4	4.4	0.699					
4021	5	4	5	5	4	3	5	5	4	3	4.3	0.823					
5220	5	5	5	2	4	5	5	5	5	5	4.6	0.966			5		
3117	5	2	5	5	5	5	5	5	2	5	4.4	1.265			5		
6329	1	2	2	1	1	2	1	3	1	2	1.6	0.699					
2534	4	1	3	5	5	3	3	5	3	3	3.5	1.269					

^aSD = standard deviation

In addition, the data obtained for the high and low threat scenes were consistent with the overall data reported earlier in that there were no differences between viewing conditions.

The most reasonable conclusion is that the phenomenon, if it exists, of speaking louder when NVGs are worn could not be reproduced in the laboratory experiment, which suggests that it is not related to the physical characteristics of the viewing device alone.

Table 5

Rms Voice Level (dBA) for Scene Content on High Threat (T5)
and Low Threat (T2) Scenes Only

Subjects	Viewing conditions and threat level									
	70 NVG		40 NVG		MOCK		HARN		NONE	
	T5	T2	T5	T2	T5	T2	T5	T2	T5	T2
1	83.6	82.1	81.6	80.7	80.6	79.9	76.4	77.5	80.2	78.6
2	81.9	81.0	84.2	82.4	86.0	84.3	86.5	84.8	83.8	81.4
3	82.1	83.4	81.6	81.0	84.6	84.0	84.1	82.0	78.9	78.7
4	80.0	77.2	81.2	81.8	81.0	78.6	82.2	80.2	79.0	77.7
5	85.3	84.7	82.1	81.2	83.0	81.8	83.3	83.1	81.8	80.3
6	71.0	70.6	69.6	70.1	71.7	70.8	73.1	73.3	73.7	73.5
7	66.8	64.2	69.4	70.0	71.7	70.6	71.0	70.0	71.5	71.5
8	79.8	75.6	83.8	79.5	80.3	78.3	81.7	79.5	76.1	72.1
9	76.5	74.7	73.7	74.4	79.0	77.6	81.0	80.0	77.2	76.4
10	80.4	81.7	77.6	75.0	77.8	77.0	81.7	80.9	79.0	80.1
11	78.6	79.7	81.1	79.6	81.1	81.9	82.4	82.1	81.1	81.0
12	78.8	76.6	80.1	78.6	78.8	78.5	78.5	77.9	78.7	77.2
13	62.6	64.6	64.8	64.2	62.5	61.1	63.5	64.0	66.5	67.8
14	59.2	58.9	58.5	58.5	60.7	61.1	63.3	64.3	61.0	60.7
15	83.1	82.3	83.6	84.2	81.4	80.6	81.2	81.0	85.3	84.8
16	80.0	77.8	80.0	78.0	77.3	76.5	78.0	78.1	78.5	78.5
17	75.7	74.2	77.9	78.0	76.7	77.8	76.6	76.5	75.6	74.0
18	83.4	85.2	86.9	83.7	84.7	84.7	84.4	83.5	83.4	85.0
19	85.4	77.6	85.9	81.1	86.2	84.0	83.8	78.2	82.2	80.3
20	54.5	52.9	50.0	51.3	54.8	52.9	55.3	55.0	52.5	52.7
SUM	1528.7	1505.0	1533.6	1513.3	1539.9	1522.0	1548.0	1531.9	1526.0	1512.3
MEAN	76.4	75.3	76.7	75.7	77.0	76.1	77.4	76.6	76.3	75.6
SD	8.9	8.9	9.7	8.8	8.7	8.7	8.3	7.7	8.1	7.9

Table 6

Rms Voice Level (dBA) for Identification Numbers on
High Threat (T5) and Low Threat (T2) Scenes Only

Subjects	Viewing conditions and threat level									
	70 NVG		40 NVG		MOCK		HARN		NONE	
	T5	T2	T5	T2	T5	T2	T5	T2	T5	T2
1	81.7	81.7	80.4	77.6	76.0	77.8	74.1	75.7	76.6	78.7
2	78.1	80.8	80.4	79.6	84.1	80.7	82.7	78.5	78.6	77.9
3	85.3	82.3	82.8	81.2	84.6	85.9	83.5	80.8	83.4	82.1
4	78.4	79.0	83.3	81.8	81.6	76.5	81.2	83.3	79.8	80.8
5	84.6	85.1	80.7	81.1	82.4	81.2	84.3	81.6	80.7	81.2
6	71.7	71.6	72.8	71.2	74.1	72.6	74.4	75.2	75.2	73.9
7	69.6	68.4	72.9	72.1	77.4	73.3	71.7	71.2	73.0	73.9
8	81.8	71.8	76.2	77.3	74.2	75.8	81.2	77.1	72.3	70.2
9	80.2	76.6	80.3	79.5	82.0	82.2	81.6	82.4	79.3	78.4
10	78.2	79.7	77.7	77.6	76.8	77.1	83.4	80.6	83.2	79.4
11	78.4	78.8	79.9	76.2	81.0	78.2	78.0	81.6	81.8	79.4
12	76.1	79.5	77.7	78.6	79.2	75.9	80.2	72.5	75.3	76.8
13	62.0	61.3	61.8	62.5	61.1	61.5	63.1	59.1	63.8	64.0
14	60.2	60.6	60.9	59.1	61.1	62.2	64.4	62.8	60.9	63.7
15	82.1	80.4	84.4	85.0	81.1	80.9	81.8	80.3	85.2	82.4
16	79.9	80.4	80.6	78.1	79.1	76.5	78.7	79.0	79.3	79.2
17	75.0	74.7	76.5	74.8	75.7	77.1	75.8	72.8	73.6	72.7
18	86.6	84.6	82.1	83.3	85.0	84.3	86.1	83.1	86.0	84.9
19	80.6	79.8	78.8	80.3	81.3	80.6	76.7	75.4	77.1	79.0
20	62.2	59.3	59.9	60.1	61.1	62.8	63.3	62.4	62.4	59.2
SUM	1532.7	1516.4	1530.1	1517.0	1538.9	1523.1	1546.2	1515.4	1527.5	1517.8
MEAN	76.6	75.8	76.5	75.9	77.0	76.2	77.3	75.8	76.4	75.9
SD	7.7	7.9	7.4	7.4	7.6	6.9	7.0	7.2	7.2	6.9

Table 7
Rms Peak Voice Levels (dBA) in High Threat (T5) and Low Threat (T2) Scenes Only

Subjects	Viewing conditions and threat level									
	70 NVG		40 NVG		MOCK		HARN		NONE	
	T5	T2	T5	T2	T5	T2	T5	T2	T5	T2
1	84.6	85.1	80.9	82.8	81.8	83.9	77.0	76.8	81.7	79.4
2	86.8	82.8	85.2	84.3	87.7	83.5	85.2	78.1	85.7	81.8
3	85.0	82.9	82.7	83.4	86.1	88.8	86.9	81.8	81.0	81.2
4	81.3	78.8	81.3	83.5	85.2	79.8	84.0	82.1	82.1	79.8
5	89.6	86.1	85.1	83.6	85.1	81.0	86.0	83.8	82.5	83.0
6	70.5	72.1	70.5	73.9	71.2	71.5	73.8	72.4	74.7	76.1
7	66.2	64.9	68.4	71.3	73.1	72.8	71.1	70.5	73.3	74.8
8	84.4	77.3	88.9	81.3	81.8	79.3	84.4	80.7	79.1	75.6
9	78.2	75.8	74.4	70.9	80.2	79.8	82.0	83.5	76.6	76.7
10	83.4	83.1	81.1	78.1	79.9	77.8	82.1	83.5	81.3	81.0
11	81.7	81.2	83.1	79.0	82.8	84.0	84.9	82.9	82.8	83.8
12	78.0	78.5	84.1	81.9	78.8	79.0	82.7	78.1	75.9	79.5
13	65.5	67.3	69.3	67.6	64.7	63.9	66.8	65.3	67.1	69.4
14	61.0	59.4	58.8	60.4	61.8	65.0	65.1	64.9	61.7	62.1
15	83.4	83.9	81.8	85.3	80.7	79.7	81.0	80.4	84.8	84.3
16	78.0	79.4	81.0	79.8	77.6	76.6	75.9	78.1	80.4	79.1
17	76.1	74.9	77.9	79.6	77.6	77.7	77.6	76.8	74.5	75.2
18	83.5	85.7	86.9	83.8	82.3	83.8	82.1	84.4	81.5	83.4
19	87.3	76.6	90.9	82.1	90.7	84.4	85.3	79.2	82.5	79.6
20	56.6	52.9	52.8	53.2	55.0	57.0	57.5	56.2	53.3	54.9
SUM	1561.1	1528.7	1565.1	1545.8	1564.1	1549.3	1571.4	1539.5	1542.5	1540.7
MEAN	78.1	76.4	78.3	77.3	78.2	77.5	78.6	77.0	77.1	77.0
SD	9.3	9.1	9.9	8.7	9.0	7.9	8.0	7.5	8.2	7.4

GENERAL DISCUSSION

The primary objective of this experiment was to determine if the phenomenon of increased voice level associated with NVG use could be reproduced in the laboratory during more controlled conditions than would be available in the field. If so, it would provide information about whether the phenomenon had any basis in the purely physical aspects of using NVG displays. The authors were not able to capture the phenomenon in the laboratory. There are certain critical factors, however, that exist in field situations and create the context of the original reports of the phenomenon. First, in the laboratory, the observer cannot move through the terrain. The active physical effort exerted while performing such a

task could influence voice level. Second, the space surrounding the observer in the laboratory cannot be totally darkened, as it would be outdoors at night, because of the reflected light spill of the video projection method used to present the stimuli. For an effect of attentional tunneling to take place, sufficient perceptual isolation of the central task of examining a bright display in the darkness of the surrounding environment may be necessary. Third, the stress of a real viewing situation cannot be duplicated in the laboratory. The NVG user on a stealth night mission, playing the role of "the eyes of the squad," is in a highly stressful situation by definition. Just walking through the woods at night while wearing the NVGs, with a limited FOV, trying not to trip on ground obstacles or to be hit in the face by branches of trees is not a casual task. Stress is also increased by the possible detection by an enemy and the responsibility of the NVG user for the survival and safety of the other squad members. Perhaps stress itself may indirectly influence voice level through an effect on general muscle tension, thereby making voice level control more difficult. Also consider that the rest of the squad normally do not wear NVGs and are following the lead observer. They have to play the role of "the ears of the squad" and pay extra attention to the sound of the surroundings. That factor and the fear of discovery by the enemy may create a situation in which even the softest verbal utterance by the NVG user might sound too loud to the listener. This constitutes another possible facet of the phenomenon. The NVG wearer may or may not speak louder than normal in a stealth context, but the same context may also contribute to the phenomenon by causing the speaker to sound louder than normal to the listener.

A secondary objective of constructing a dynamic, visual target acquisition task involving targets at close range did prove successful in immersing observers who wore NVGs in the scene context. Observer behavior such as responding to a perceived threat can be more insightful of the kinds of scenarios that soldiers might face in the field. Visual target acquisition tasks typically used in a laboratory are static, single-frame search tasks that may not sufficiently involve the observer. Even when natural scenes are used, the observer's task is usually to search for and to find a stationary target (typically a distant vehicle) and then to be presented with a new scene. In a more realistic target acquisition task in which the natural scene is continually changing, there is a sense of time passing, and the dynamics of continual scene change and the uncertainty of a target appearance may be more realistic and more formidable factors which affect human expectancy in target acquisition performance. Such dynamic elements should be used in future scene development for target acquisition studies. The authors also learned that when "targets" (e.g., other soldiers) are near enough to the observer to elicit an immediate response, not only the presence of the target but also the nature of its activity and context should be considered as factors in more realistic presentations.

Further investigation of the phenomenon of louder speech level associated with the wearer of NVGs is planned for the near future. The authors hope that the source of the phenomenon can be found outdoors in a realistic field scenario involving the uncertainty of a natural environment, the isolation of nighttime darkness, and the stress of being discovered.

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APPENDIX
INSTRUCTIONS

INSTRUCTIONS

(To be read to the observer, with some notes on Procedures).

We're interested in seeing how soldiers find targets.

In this experiment, we want to see how soldiers find targets wearing night vision goggles, and we'll do this in this room.

I'll show you some short scenes of wooded areas, woods. You need to imagine that you're actually in the scenes, in the woods, watching what's going on.

There may be one or more soldiers, or no soldiers, in the woods and, the soldiers may be motionless or moving.

Imagine YOU are the lead observer in a Special Forces Team. You're on a night mission with other squad members following behind you.

It's YOUR responsibility to observe any military activity you might see and to describe it to the next squad member behind you.

You're the only soldier in the squad wearing night vision goggles so you're the eyes of the squad.

You must not only notice as much as possible of what might be going on out there, but must also communicate this information to another person who can't see what you see.

You need to report what you see, quickly, AS YOU SEE IT, not after you've seen it.

MOST important is how ACCURATE you are in describing what you see. It could affect everybody's survival.

SOMETIMES, it might look like a soldier you see in the scene is doing something with a weapon. We'd like you to report what direction you think the soldier is aiming at, to your left, or right, or maybe at you and, how far he is from you.

SOMETIMES, the soldier may be moving left or right or toward you. You need to report which way he's moving and at what distance.

It might SOMETIMES look like YOU were noticed by the soldier you see. If you think that he saw you, you need to report that also.

SOMETIMES, a soldier or soldiers may be just standing there. You need to report where they are and at what distance.

AND, SOMETIMES, it might look like there's nothing at all going on. You just report there's no military activity or it's all clear, and it's safe to continue.

Any questions so far, about what we're asking you to do?

For this experiment, you wear three different goggles or no goggles.

You stand on this platform to watch the scenes.

You see 6 scenes for each set of goggles you wear or while not wearing any goggles.

Some of the goggles are night vision goggles.

We'll be testing 5 conditions, with and without goggles. I'll tell you more later.
Remember, we want to compare how it is to find a target wearing goggles with how it is to
find a target without wearing goggles.

Any questions?

Here's the procedure:

FIRST, you see a 4-digit number in front of you. It's large.
You can't miss it.

You tell me those digits.

The digits are visible for about two or three seconds.

Tell me them one digit at a time, like 4-1-8-3.

Don't wait until they're gone. Tell me while they're there.

I'll be standing near the wall behind you, in back of this partition, writing the number you
say, so that we're certain which scene you're looking at.

THEN, about two seconds after the numbers disappear, the scene begins.

YOUR job is to imagine YOU are actually in those woods, observing anything of military
importance and describing what you see, AS YOU SEE IT, to another squad member, me,
standing behind you.

If you see a soldier in the scene:

FIRST; tell me his LOCATION: "soldier, 9 o'clock (or 3 o'clock, or 12 o'clock, wherever the
soldier is... (EXPLAIN TO S)

THEN; tell me his DISTANCE from you: in meters or feet or yards, whatever unit you like,
but use the same unit each time. Make your best guess of the distance.

THEN; in any order, tell me his ACTIVITY;

which way he's moving, if he is, OR if he's not moving,

which way you think a weapon is pointing, if you see one,
and, judging from his behavior, if you think HE sees YOU.

AFTER about 20 seconds, the scene disappears.

That's the end of it. I'll be writing down the information you gave me. I won't be talking to
you during the tests while you're seeing the scenes.

The next scene begins in 5 or 10 seconds.

You see a new four-digit number, which you tell me.

After 2 more seconds, the new scene begins, you tell me what you see, the scene ends, and so on. In reality, the scene would be continuous and you'd continuously report what you're seeing if it's important.

After you see 6 scenes, we change conditions and look at another set of 6 scenes. When you've looked through all the goggles, and looked at some scenes without goggles, you'll be finished with the experiment.

This whole procedure should take about 20 minutes.

Any questions?

Before we start the experiment, I'll show you a few scenes so you can get an idea of the task you're being asked to do.

(MIKE ATTACH:)

This is for later on, when we want to analyze what kind of language people use in their descriptions of what they see and, in case I miss writing down some important notes on your descriptions.

(ON PLATFORM:)

Remember, I can't see any part of the scene that you see.

Describe to me everything that you think is important.

TO REPEAT, four digits. Tell me what they are, one at a time.

THEN, the scene. Start telling me what you see.

LOCATION: If there's a soldier, moving or not, tell me where he is, from 9 o'clock to 3 o'clock.

DISTANCE: Tell me how far away he is.

ACTIVITY: Tell me what he's doing. If he has a weapon which way is he pointing it?

If he's moving, what direction. Is he not moving?

Did he see you?

O.K.? Here's the first scene. After it we stop for questions.

(SHOW SAMPLE 1:)

Any questions? That was pretty good.

Remember, If you see a soldier in the woods, moving or not, report Location, Distance, and Activity.

Let's try another scene. Watch for the numbers.

Here it is.

(SHOW SAMPLE 2:)

Location, Distance, Activity.

O.K. Good. Any questions?

During the actual experiment, I won't be talking to you.

Let's try one more scene. This time I won't prompt you. See how much you can report accurately to me, without my saying anything.

Ready? Here's the scene.

(SHOW SAMPLE 3:)

Any questions?

We're now ready to begin the actual experiment.

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13. ABSTRACT (Maximum 200 words) There have been numerous undocumented reports that military users of night vision goggles (NVGs) tend to talk louder than usual when they wear the viewing device. Increased voice level in response to using the night vision aid could seriously compromise the security of military missions that depend upon stealth for their success. The goal of this study was to investigate the effects of characteristics of the NVGs such as display resolution, field of view, and physical constraint on the voice level of NVG users as the users described military activity of potential targets seen during a visual target acquisition task. The experiment was conducted indoors without the presence of situational variables or psychological stressors ordinarily found in the field. The authors wished to determine whether voice level depended on the physical characteristics of the NVGs. No effect of physical characteristics of the NVGs was observed. The influence of situational variables on the vocal output of NVG users will be examined in a future experiment. Some aspects concerning the procedures used to measure voice levels and to develop a realistic visual target acquisition task are discussed.			
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